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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

INVENTOR(S)			
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☐. *Additional inventors are being named on the ______ separately numbered sheet(s) attached hereto*

TITLE OF THE INVENTION (500 characters max)

VALVED MOISTURE BARRIER

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WASHINGTON OFFICE

23373

CUSTOMER NUMBER

ENCLOSED APPLICATION PARTS (*check all that apply*)

☑ Specification	*Number of Pages*	12	☐ CD(s), Number	
☐ Drawing(s)	*Number of Sheets*		☐ Other (specify)	
☐ Application Data Sheet. See 37 CFR 1.76				

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☑ Applicant claims small entity status. See 37 CFR 1.27.

☑ A check or money order is enclosed to cover the Provisional filing fees. The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to **Deposit Account No. 19-4880**. Please also credit any overpayments to said Deposit Account.

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

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☐ Yes, the name of the U.S. Government agency and the Government contract number are:

Respectfully submitted,

SIGNATURE ____________________ DATE November 3, 2003

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USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

VALVED MOISTURE BARRIER

ABSTRACT

Conventional advice is to place the moisture barrier for thermal insulation on the warm side – to avoid dewpoint condensation. With heating and cooling seasons this has not explicitly been done. This invention includes a moisture barrier bypass leakage valve such that the moisture barrier is always on the warm side.

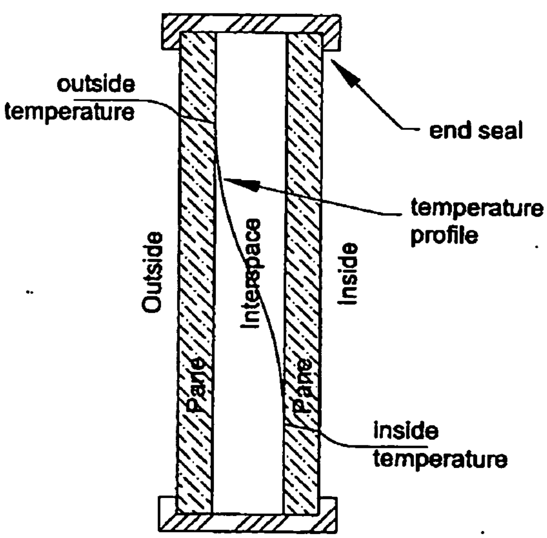

Figure 1

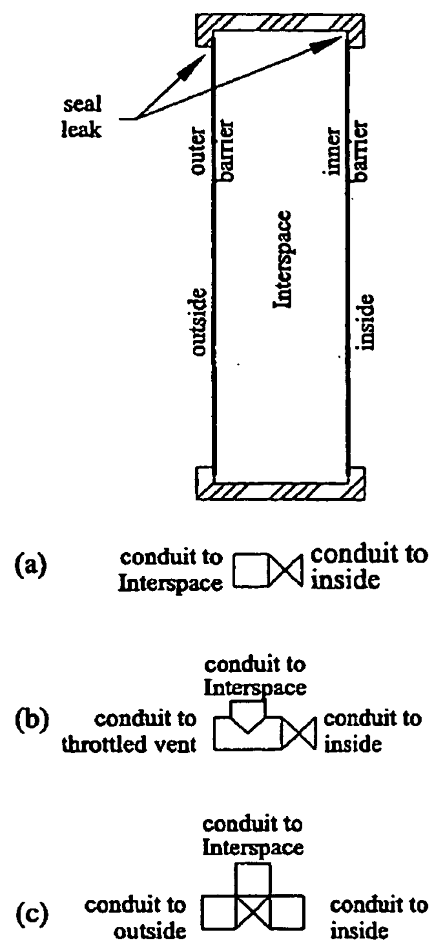

Figure 2

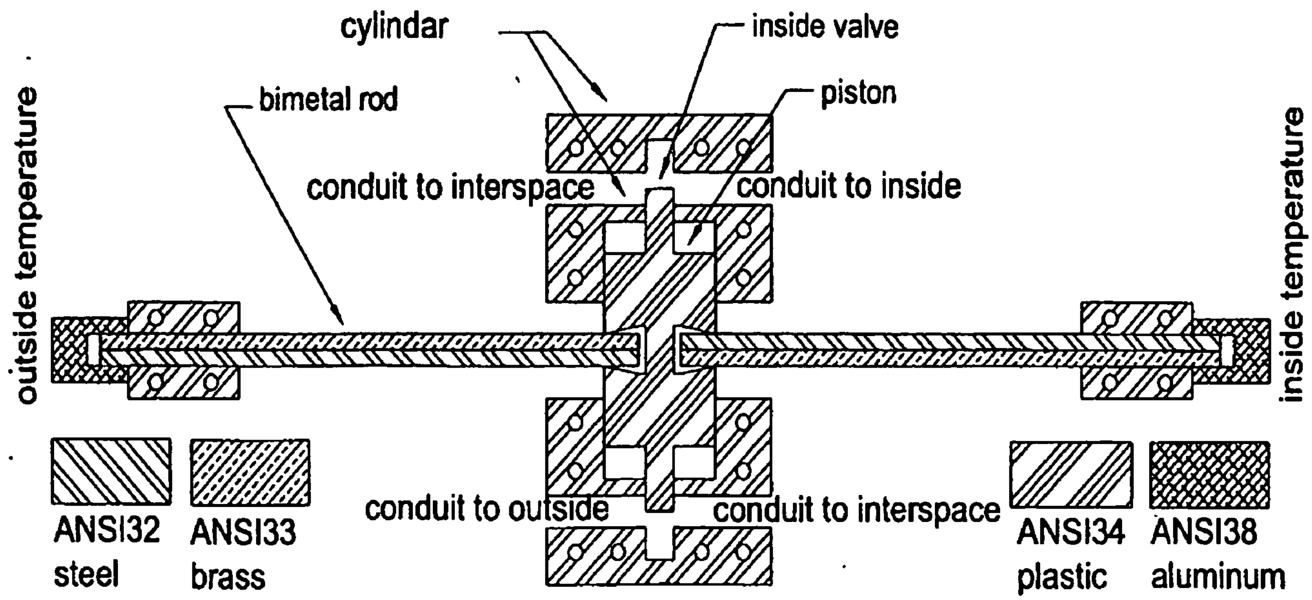

Figure 3

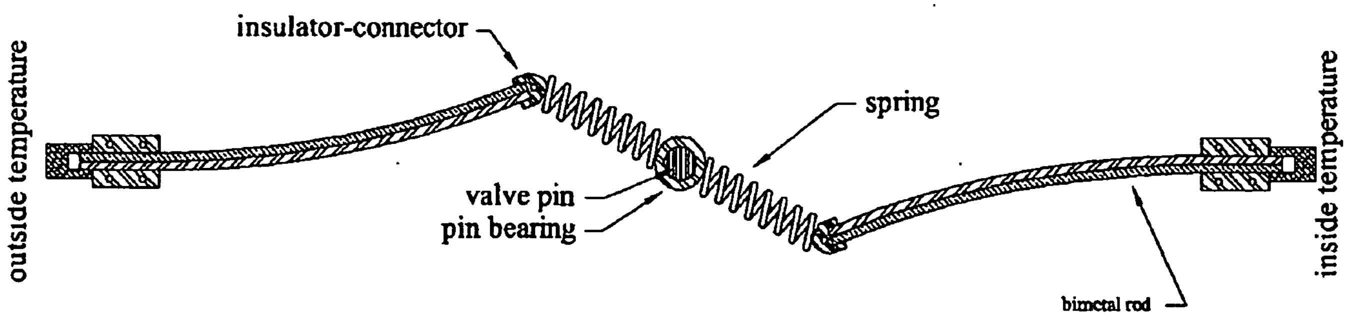

Figure 4

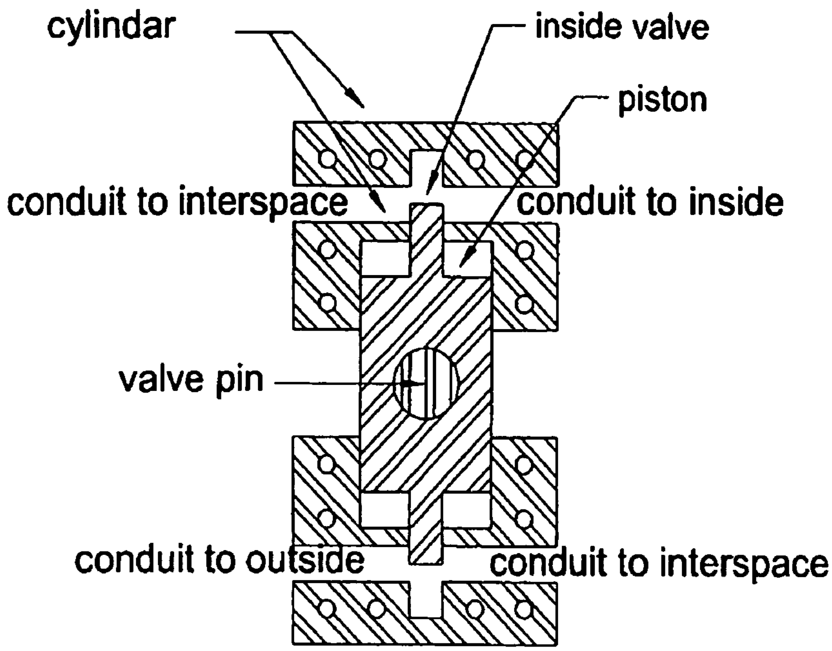

Figure 5

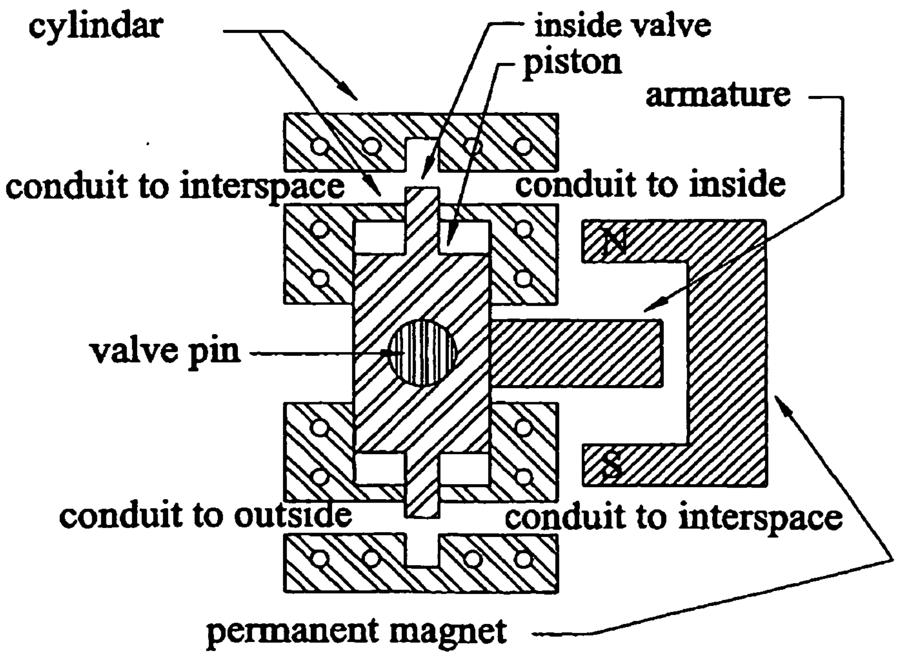

Figure 6

INTRODUCTION

For building insulation it has long been recommended that the moisture barrier be placed on the warm side. Usually the barrier is placed on the inside boundary of the insulation, since heating has historieally been the major concern. Now that buildings have both heating and cooling seasons, the recommendation cannot be fully followed.

Relative humidity on the outside cannot exceed 100 percent. During heating season temperature in the insulation is at least slightly higher than on the outside. Hence, by venting to the outside (ie, moisture barrier on the inside) via a leakage valve, the temperature in the insulation can never fall to the dewpoint. During cooling season it is reversed: venting to the inside (ie, moisture barrier on the outside) again provides humidity that cannot reach the dewpoint in the insulation. If these changes in venting are not met, dewpoint can be reached in the insulation, damaging the insulation and offering a bed for mold and germ infestation.

The subject invention places the insulation within an Interspace that is enveloped by moisture barrier – and adds one or two leakage bypass valves, such that venting is always to the coolside. The simplest implementation is a manual lever or knob on the leakage valve to switch between inside and outside venting. An automated implementation uses inside and outside temperature sensors such that the inside/outside differential temperature determines which side is vented.

The invention is applicable to thermopane windows, where glass panes are the moisture barrier and air in the Interspace is the insulation. Without coolside venting during the cooling season, when the the warm outside humidity is high, condensation occurs on the Interspace side of the cooler inside pane. Inevitably the condensation streaks and cannot be cleaned; the remedy is costly: thermopane replacement.

THERMOPANE

Thermopane provides a clear demonstration of the problem, as shown in Figure 1. The Figure depicts a warm outside temperature and a cool inside temperature, with intermediate temperature in the Interspace sandwiched between the panes. A temperature profile is shown. The outside temperature dips near the outer pane owing to gravity convection (air is warmed along a warm surface, and rises; is cooled along a cool surface, and falls). If air circulation is owing to gravity convection only (ie, there is no wind), the temperature dips in the thermal boundary layer. An analogous dip takes place on the inside surface of the outer pane, and on both sides of the inner pane.

With the Interspace insulation consisting of air, gravity convection sets up circulating air currents (the principal means of heat transmission through gaseous insulation). Vacuum in the Interspace is ideal but requires impracticably thick glass. Dry gas (eg argon) trapped in the Interspace avoids the condensation problem; but vacuum or dry gas requires impracticably perfect and durable seals. The usual thermopane uses air in the Interspace, vented such that the air pressures (ie partial pressures of air constituents – nitrogen, oxygen, ...) are the same on the outside, the Interspace, and the inside – to avoid stressing the panes. However, water vapor is the one air constituent where the partial pressures are not the same in the three regions.

Vapor pressure is uniform in the Interspace, equal to p_s, owing to convection currents. Having the "moisture barrier on the warm side" is technically equivalent to "equalizing the vapor pressure in the coolside and Interspace regions". The coolside leakage valve is the means for doing this. An object of this invention is control of water vapor pressure in the interspace.

CONVENTIONAL INSULATION

For conventional building insulation there is no need for a transparent moisture barrier. Further, convection currents within the Interspace are substantially reduced. To foster adequate convection it may be useful to: (1) use leakage valves at the top and bottom of the Interspace; or, (2) explicitly provide adequate convection circulation paths in the insulation.

THEORY

In a moisture barrier membrane, the (water) vapor leakage flowrate q, per unit area, is

$$q = \alpha\Delta p\,, \tag{1}$$

where α is the leakage conductivity per unit area, and Δp is the vapor pressure difference across the barrier. For a membrane of surface area A, the overall leakage Q is

$$Q = qA = C\Delta p\,, \tag{2}$$

where the leakage (flow) conductance C is

$$C = \alpha A\,. \tag{3}$$

Leakage Q_s around the barrier's end seals is

$$Q_s = C_s\Delta p\,, \tag{4}$$

where C_s is the end seals' leakage conductance.

At pressure equilibrium, continuity requires that the sum of all leakage across the entire membrane (ie, inside and outside barriers) be zero. Hence, for an Interspace bounded by an inside and outside barrier, the Interspace vapor pressure p_s is

$$p_s = (p_iC_i + p_oC_o)/(C_i + C_o) \tag{5}$$

where p_i and C_i are respectively the inside's vapor pressure and barrier conductance; and p_o and C_o are the outside's. For a perfect moisture barrier, conductance C is zero.

When we add bypass leakage valves (ie, inside and outside throttleable vent valves) the Interspace vapor pressure p_s is

$$p_s = [p_i(C_i + C_{si} + C_{vi}) + p_o(C_o + C_{so} + C_{vo})]/[\,C_i + C_{si} + C_{vi} + C_o + C_{so} + C_{vo}]\,, \tag{6}$$

where C_{si} and C_{vi} are respectively the inside's seal and leakage valve conductances; and C_{so} and C_{vo} are the outside's. Hence,

$$p_s = p_i \qquad \text{for } (C_o + C_{so} + C_{vo})/(C_i + C_{si} + C_{vi}) \ll 1\,, \tag{7a}$$

$$p_s = p_o \qquad \text{for } (C_i + C_{si} + C_{vi})/(C_o + C_{so} + C_{vo}) << 1 . \qquad (7b)$$

Throttleable leakage valves can be adjusted such that Interspace pressure p_S can be anywhere between p_i and p_o.

Note that the inside barrier's inherent leakage conductance $C_i + C_{si}$ (owing to porosity and leaky seals) need not be stringently low; rather $C_i + C_{si}$ should simply be low compared to C_o, the open conductance of the outside leakage valve. Thus, poor and degraded seals are relatively unimportant. Stated otherwise, the outside leakage valve's open conductance need not be exceedingly high; rather it simply need be high compared to the inside barrier conductance. Thus, with reasonably low barrier and seal conductance, the leakage valve mechanisms can be quite small. They need only be large enough to prevent substantial pressure stress to the barrier owing to changing barometric pressure.

IMPLEMENTATION

Implementation to control water vapor pressure involves a single leakage valve which can be opened or closed manually, as shown in figure 2a The simplest valve arrangement has fixed outside leakage (via seals and/or barrier porosity). A single leak valve to the inside is shown. When the leakage valve is shut, the fixed outside leakage establishes Interspace vapor pressure p_s equal to outside vapor pressure p_o – which is equivalent to having the moisture barrier on the inside. When the valve's leakage is open, set large compared to the fixed outside leakage, then p_s is effectively the same as the inside pressure p_o – which is equivalent to having the moisture barrier on the outside.

If leakage is low in the outside barrier and seal, then an explicit throttled vent should be added, as shown in Figure 2b. An advantage of separate control is that, under certain climate conditions, it may be adequate to set C_i and C_o such that the intermediate value of p_s is always above the dewpoint – even as p_i and p_o vary with humidity conditions,

Better, two valves are ganged in a bivalve – as shown in Figure 2c – such that one manual control opens-inside/closes-outside valves, and vice versa.

Figure 3 shows opposing bimetal rods as a *differential temperature actuator,* whose net motion moves a bivalve's (or, optionally, single valve's) valve piston in proportion to the inside/outside differential temperature ΔT. Full leakage valve closure occurs when ΔT exceeds a predetermined value.

Art of the bimetal is well established. If a bimetal rod is formed at temperature T_f, the rod is straight at T_f, and curves one way or the other when the temperature T is above or below T_f. Figure 3's straight bimetal rods are formed at the same T_f; but are constrained not to bend when the bucking rods are both at a temperature different from T_f, and ΔT is zero. The attached valve piston moves up or down symmetrically as ΔT is positive or negative.

It may be well to bias the bivalve in favor of the inside vent. This can be done by using bimetal rods whose T_fs are different: the bucking rods are straight when ΔT is the same as the difference in T_f s. Alternatively, Figure 3's coupled pistons can be constructed unsymmetrically.

The reason for inside bias is that outside relative humidity may reach 100 percent; inside humidity in an air conditioned environment is never close to that (ie inside dewpoint is considerably less than inside temperature). Thus inside venting will not result in Interspace condensation until outside temperature is considerably less than inside temperature.

If $|T - T_f|$ is too large, figure 3's configuration might cause strains that exceed the bimetal's elasticity limit. Figure 4's differential temperature actuator leaves each bimetal rod unconstrained. The rods' endpoints are connected by an insulated spring: the spring's midpoint is connected to Figure 3's piston, which

is reproduced, with connection pin, in Figure 5. Figure 5 shows ANSI34 plastic as the piston, because it thermally isolates the valve from the rods' temperature differences.

A sophisticated implementation involves wristwatch-sized electronics – with a variety of temperture and humidity inputs from inside, outside, and Interspace – which actuate inside and outside microvalves for optimal vapor pressure control.

FIGURES

Figure 1 depicts a thermopane window, and shows the temperature profile when the outside temperature is warm, and the inside cool. Gravity convection in the outside air causes the air to fall when cooled by the outside pane, causing a boundary layer dip in temperature at the outside pane. Gravity convention in the Interspace causes air circulation, and accounts for the somewhat nonlinear temperature profile. The inside boundary layer is also shown.

Figure 2 depicts a usual moisture barrier – where conventional insulation may fill the Interspace and convection currents are reduced. The simplest valve arrangement has fixed outside leakage (via seals and/or barrier porosity). A single leakage valve to the inside is shown in Figure 2a. When the leakage valve is shut, the fixed outside leakage establishes Interspace vapor pressure p_s equal to outside vapor pressure p_o – which is substantially equivalent to having the moisture barrier on the inside. When the valve's leakage is set large compared to the fixed outside leakage, then p_s is substantially the same as the inside pressure p_i – which is substantially equivalent to having the moisture barrier on the outside.

If leakage is low in the barrier and seal, then an explicit throttled vent should be added, as shown in Figure 2b. Alternatively, Figure 2c shows a single *bivalve* – with conduits to inside, outside, and Interspace – which can be switched to inside or outside.

Figure 3 shows a leakage *bivalve* (alternatively, single valve) connected to a constrained differential temperature actuator, discussed above.

Figure 4 shows an unconstrained differential temperature actuator. Its pin bearing accommodates Figure 5's valve pin, as shown.

Figure 5 shows Figure 3's bivalve, with a pin to connect to a manual or a differential temperature actuator

Figure 6 shows a *bistable bivalve* (alternatively, single valve). The armature has two stable positions: nearest the permanent magnet's : (1) North pole; or (2) South pole. A differential temperature actuator, via the spring connection shown in Figure 4, forces it to one or the other position.

DRAFT CLAIMS

1. Thermal insulation with means to control vapor pressure therein.
2. Claim 1, with a moisture barrier.
3. Claim 2, with a leakage valve.
4. Claim 2, with an Interspace bounded by an inside and an outside moisture barrier.
5. Claim 1, with an Interspace bounded by an inside and an outside moisture barrier, with a leakage bivalve.
6. Claim 5, with a differential temperature actuator.
7. Claim 1, with an Interspace bounded by an inside and an outside moisture barrier, with a bistable leakage bivalve.
8. Claim 7, with a differential temperature actuator.

REFERENCES

4,649,685
5,270,092
6,613,404

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PREPROPOSAL 031103

VALVED MOISTURE BARRIER

ABSTRACT

Conventional hygrothermal advice is to place the moisture barrier for thermal insulation on the warm side – to avoid dewpoint condensation. With heating and cooling seasons this has not explicitly been done. We propose insulation fully enclosed by a moisture barrier, plus inside and outside bypass leakage valves – actuated by a differential temperature bimetal – such that the moisture barrier is always on the warm side. The mechanism can be sized small to fit within a thermopane window, or larger to service hundreds or thousands of square feet of envelope insulation.

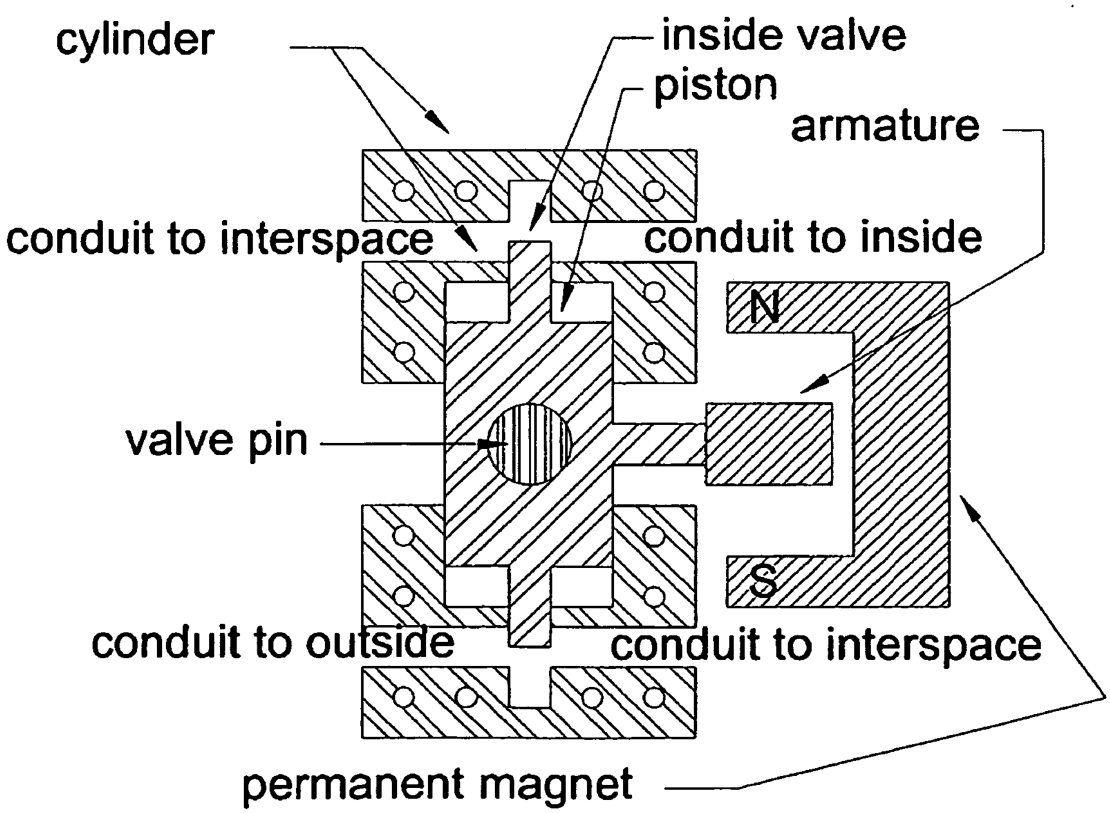

Figure 1. An inside-outside bivalve, with magnet means to make the valve bistable. Only stable positions for armature are: (1) nearest to North pole; or, (2) nearest to South pole. Figure 2's pin bearing actuates bivalve.

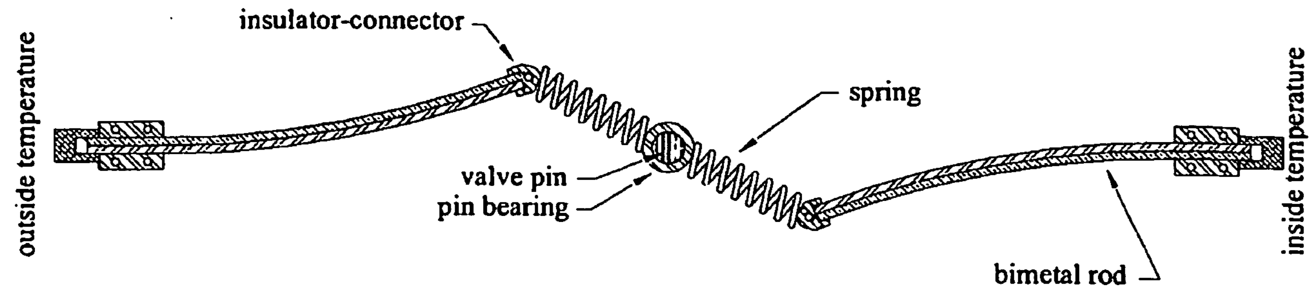

Figure 2. Differential temperature bimetal valve actuator, shown in its neutral position, when differential tèmperature is zero.

INTRODUCTION

Relative humidity (RH) on the outside does not exceed 100 percent. During heating season, temperature in the insulation is at least slightly higher than on the outside. Hence, by venting to the outside (ie, moisture barrier on the inside) via a leakage valve, the temperature in the insulation can never fall to the dewpoint. During cooling season it is reversed: venting to the inside (ie, moisture barrier on the outside) again provides humidity that cannot reach the dewpoint in the insulation.

If these changes in venting are not met, dewpoint is reached in the insulation, causing damages cited by <<http://www.ornl.gov/roofs+walls/research/envelope.htm>>:

"Building materials, like all other materials around us, have different affinities toward storing moisture. As moisture accumulates within the building envelope assembly, the energy efficiency can be reduced by up to a factor of three, or even more if evaporation and condensation occur inside the envelope. If moisture accumulates above a critical material-dependent threshold, the building components begin to rot, corrode, or otherwise degrade in structural or functional integrity. Damage induced by moisture includes rotting of wood studs and other components, corrosion of steel frame members, salt transport, mold growth, and efflorescence. Such damage is related to the inability of the building owner to control moisture within acceptable limits".

The proposed device is applicable to thermopane windows, where glass panes are the moisture barriers and air in the Interspace is the insulation. Without coolside venting during the cooling season, when the warm outside humidity is high, condensation occurs on the Interspace side of the cooler inside pane. Inevitably the condensation streaks and cannot be cleaned; the remedy is costly: thermopane replacement.

A modicum of convection current within the Interspace is needed – to assure that the vapor pressure is uniform throughout.

Having the moisture barrier on the warm side is technically equivalent to having the Interspace vapor pressure equal to the coolside vapor pressure. The coolside leakage valve is the means for doing this.

THEORY

It can be shown that the vapor pressure p_s within the insulation – ie within the Interspace sandwiched between the inside and outside moisture barriers – is

$$p_s = (p_i C_i + p_o C_o)/(C_i + C_o), \tag{1}$$

where p_i and p_o are respectively the inside and outside vapor pressure; and, C_i and C_o are respectively the leakage flow conductances of the inside and outside leakage valves. Hence,

$$p_s = p_i \qquad \text{for } C_o/C_i \ll 1\,, \tag{2a}$$

$$p_s = p_o \qquad \text{for } C_i/C_o \ll 1\,. \tag{2b}$$

When a valve is shut its leakage flow conductance is zero. Throttleable leakage valves can be adjusted such that p_s can be anywhere between p_i and p_o.

Poor and degraded seals become relatively unimportant. The coolside leakage valve's full open conductance need not be exceedingly high; rather it simply need be high compared to the leakage flow conductance of the seals and barrier membrane. Even with a degraded moisture barrier, the leakage valve mechanisms can be quite small. They need only be large enough to track vapor pressure changes and to prevent substantial pressure stress to the barrier owing to changing barometric pressure.

A small valved barrier system is envisioned for a thermopane window; larger for several hundred sq ft of batt; largest for roof or attic insulation. In an attic, for instance, the moisture barrier is painted all around, and the Valved Moisture Barrier System consists of three modules: (1) coolside thermometer and leakage valve(s), possibly with fan; (2) similar for warm side; (3) control unit to ascertain differential temperature (ΔT) and actuate the leakage valves (and fans).

Saturation water vapor pressure about doubles for every 10 degrees Celsius. Stated otherwise, if inside RH is 50%, then the dewpoint is about 10 degrees below indoor temperature; if 25%, then 20 degrees. Figure 2 displays a bimetal ΔT actuator that is symmetric when $\Delta T = 0$ – and so the leakage bivalve switches between inside and outside at $\Delta T = 0$. In practice one would modify the actuator or the bivalve such that switching occurs when the outside temperature is, say, 10 degrees cooler than inside.

FIGURES

Figure 1 shows a *bistable bivalve.* The armature has two stable positions: nearest the permanent magnet's: (1) North pole; or, (2) South pole. A differential temperature actuator, via the spring connection shown in Figure 2, forces it to one or the other position.

Figure 2 shows a bimetal differential temperature actuator. Its pin bearing accommodates Figure 1's valve pin, as shown.

STATEMENT OF WORK

1. Review of hygrothermal practice.
2. Assembly of environmental enclosure to accommodate: (1) valved thermopane; and, (2) 8-10 sq feet of valved envelope insulation.
3. Acquisition of temperature and humidity sensors.
4. Thermopane:
    - (a) Construction of valved thermopane.
    - (b) Conduct of tests simulating heating and cooling seasons, with various inside/outside temperature and humidity as parameters.
    - (c) Test the control of p_s as a function of C_i and C_o
5. Envelope insulation:
    - (a) Construction of valved insulation with inside and outside vapor barriers.
    - (b) Conduct of tests simulating heating and cooling seasons, with various inside/outside temperature and humidity as parameters.

6. Data reduction, analysis (including p_s and T_s as function of t), and Final Report – with strategies for use, and recommendations to accommodate to existing manufacturing and installation technique for thermal insulation.

DISCUSSION

The writer's extensive history of conducting R&D under government contracts and grants is over: 1995 motor vehicle accident abridged physical agility below that amenable for lab work. If this preproposal is of interest, the plan is to join with a university and submit a formal joint proposal, envisioning that the writer will be principal scientist, but that the remainder – faculty consultant and thesis advisor, graduate student, laboratory effort – will be conducted at the university.

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